SHORE LEAVE

Seaside communities spend millions fighting coastal erosion. But saving one beach often means destroying another.

BY PAUL D. KOMAR

EARLY IN THE SUMMER OF 1989 I VISITED Folly Beach, on a barrier island off the coast of South Carolina. I had lunch at the Atlantic House, which billed itself as "the restaurant above the surf," because, at high tide, its stilt-like wooden foundation pilings dived through several feet of ocean before anchoring themselves at the bottom. As I sampled the fish-and-chips, I could see breaking waves through gaps in the floorboards. Notes on the menu explained that the restaurant had originally been built on land, but that the relentless battering of the tides had so worn away the shoreline that the structure was now perched above the surf. The restaurant had survived many hurricanes in its precarious position, the menu proclaimed proudly—and perhaps overconfidently. Three months later, Hurricane Hugo hit the South Carolina coast, and I saw the remnants of the Atlantic House on national television—no longer a triumph of will over nature but just a tangle of glass and broken timbers.

As creatures of terra firma, most people expect the landscape around them to remain fixed. Homeowners stake the four corners of their lots and think they can mark their territory in perpetuity. But waves and ocean currents respect no property lines; slowly and inexorably, they push their way inward. The edges of the world's continents are being swallowed by the sea. Coastal erosion is a problem of worldwide scope, from the shores of the Mediterranean to the coasts of India, China and New Zealand.

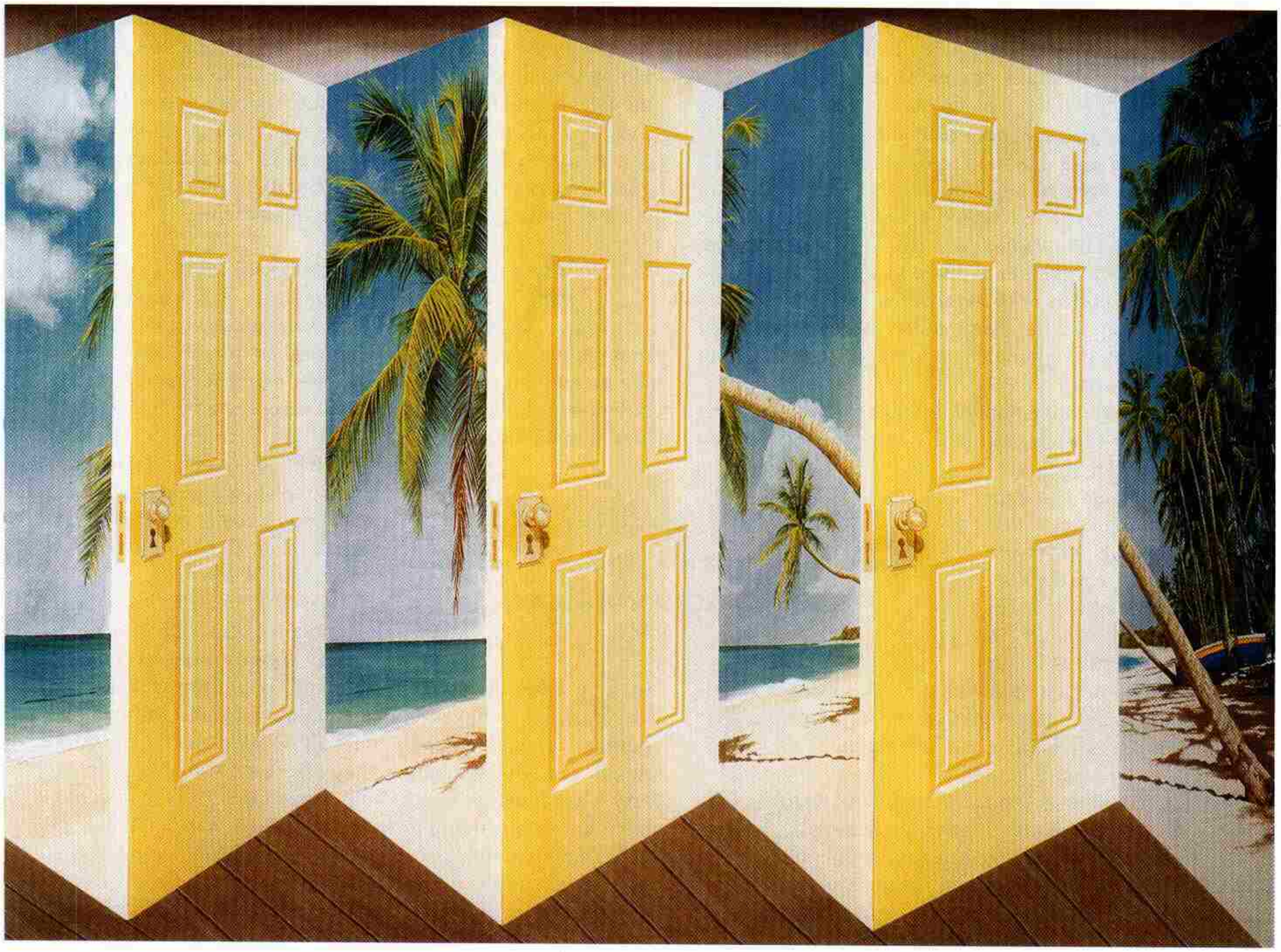
The loss of any shoreline is a natural and inevitable process, but there is a single corollary to that loss that commands immediate attention: the loss of beaches. Go to the seashore on a summer vacation, and you expect to find a wide, sandy beach: the perfect playground. But anyone who has spent much time near the ocean knows that beaches are not static entities; they are constantly shifting and readjusting themselves beneath the waves and tides. Cliffs erode, beaches narrow, and dunes wash away. If the shoreline were undeveloped, such changes would go unnoticed by everyone except the most avid sunbather or beachcomber. The sand that deserted one beach would merely migrate to an adjacent beach or cove, with no net loss.

But when beaches are backed by homes and resorts, the natural flux of the shoreline can be devastating. Go back to a vacation spot that you recall from childhood, and it is likely that the gray-shingled house on the dunes you remember so well has vanished. On the East and Gulf coasts of the United States, luxury homes and condominiums are regularly undermined or even destroyed by heavy winds and waves. In 1989 Hurricane Hugo wrought more than $7 billion in property damage, including the inland destruction by winds and floods.

The potential for storm damage today, just a few years later, has become much greater, as the construction juggernaut moves up and down the coasts, where land is being developed two to three times faster than the national average. On barrier islands such as Folly Island, fantasy homes and sprawling resorts rest on what are little more than overgrown sandbars, particularly vulnerable to the continual tug and pull of currents, tides and lashing winds. And barrier islands are everywhere, lining much of the eastern seaboard and the coast of the Gulf of Mexico; the lure of taking a vacation or making a home there is a siren song for millions of landlubbers. The place-names evoke a rich heritage of American life: from Long Island, New York, to Kitty Hawk, North Carolina, Hilton Head, South Carolina, and Cape Canaveral, Florida, along the Atlantic; and from Sanibel Island, Florida, to Padre Island, Texas, along the Gulf.

On the coast of California, meanwhile, a construction boom has created a similar potential for huge losses. During the recent storms of the 1997–98 El Niño, ten houses were lost in Pacifica, near San Francisco, and television crews hovered around Malibu, where there was a serious threat to the homes of many movie stars. Nearly $100 million in property losses was reported altogether. The beaches of southern California are disappearing, threatening the fabled lifestyle of *Baywatch* land.

Coastal communities spend millions of dollars each year combating shoreline erosion. But in my view much of that money is not well spent. Before deciding whether and how to fight an instance of erosion, one must investigate and



Patrick Hughes, Juxtaposition, *1998*

understand its true causes. A recent storm may have washed away a beach and destroyed homes lining the shore, but merely blaming the weather is simplistic. Almost always, subtle factors have been acting over time to weaken the coast and make it more susceptible; the storm, when it comes, simply delivers the coup de grâce. People have altered the environment dramatically, interfering with the natural hydrologic and geologic cycles that beaches rely on to survive. In short, we are a cause of coastal erosion, not just its victims.

As ELUSIVE AS THE CAUSES OF BEACH EROSION may be, the consequences are all too tangible. Earlier this year, after much debate, officials in North Carolina dragged the historic Cape Hatteras lighthouse a third of a mile back from the shore, where it was in danger of being engulfed by the Atlantic. When the lighthouse was built in 1870, it was about 1,500 feet away from the beach, but the intervening years had eaten the land away.

The most obvious instigator of beach erosion, a major storm, can appear in various guises. On the East Coast it usually means a hurricane or a nor'easter. The atmospheric pressure in the eye of a hurricane is much lower than it is in the areas around it, so the storm acts like a straw, sucking the ocean surface upward. The result is a storm surge that can increase water levels by between ten and fifteen feet. Hence the waves break that much higher, often crashing unimpeded against houses along the shore. On the West Coast, particularly in recent years, major storms have taken a different form: El Niño. The nasty weather associated with the El Niño pattern begins when the temperature of surface water in the tropical Pacific becomes unusually warm. The heated water expands, temporarily raising tidal levels along the coast. The high tides then combine with storm waves to grab sand and carry it offshore.

One key to understanding the erosion caused by a storm is to recognize that beaches are not entirely visible: much of the sand is hidden underwater. Large amounts of sand move in and out of a beach seasonally, in response to a variety of pressures. In the winter, frequent storms can send sand under the waves, narrowing the visible beach and creating a steep slope. Mild summer swells can restore that sand to the visible part of the beach, creating the wide expanse beloved by sunbathers. Moreover, sand not only moves in and out of the beach but along the shore as well. Waves, guided by the direction of the wind, tend to break at an oblique angle to the shore, and so sand gets picked up and deposited further up or down the coast, a phenomenon known as littoral drift. With all that shifting and even long-distance migration of sand, the stability of a beach depends on a regular influx of new sand.

When a beach erodes, people usually ask, Where has all the sand gone? But the more relevant question is, What happened to the sand that used to reach the beach? Beach erosion and its opposite, beach accretion, both depend on the constantly changing balance between the sand that arrives at the beach and the sand that leaves it. Beaches gain sand from the sediments carried by rivers that empty into the sea, and from the grains that rub off the faces of eroding cliffs. Beaches lose sand when it moves up or down the coast, or when it is carried offshore into an underwater canyon.

Coastal scientists and engineers refer to this balancing act as the "budget of beach sediments," and, in fact, a beach can be compared to the money in a checking account. Gains of sand represent credits; losses are debits. When the gains are greater than the losses, the result is beach accretion; when the account is "in the red," the result is beach erosion. The advantage of thinking about a budget of sediments is that it focuses attention on the big picture and on the long-term, underlying causes of erosion.

SEAWALLS AND JETTIES
can save homes and harbors, but they starve beaches.

THE FIRST SEDIMENT BUDGETS WERE DEVELoped in the 1960s by Douglas L. Inman, the founding director of the Center for Coastal Studies at the Scripps Institution of Oceanography in La Jolla, California, and by Anthony J. Bowen, then a student of Inman's and now an oceanographer at Dalhousie University in Halifax, Nova Scotia. Those budgets, developed using the coast of southern California as a model, showed that human activity was the problem. Dams had been built on nearly every river in the area—visitors to Los Angeles can view rivers that have been reduced to concrete channels. Hence the sand that rivers once carried to the coast is now trapped in reservoirs. Meanwhile, to protect expensive seaside homes, massive seawalls were built at the bases of the cliffs. For the beaches, though, the seawalls have the same effect as the dams: they block the natural delivery and replenishment of sand—in this case, sand from eroding cliffs. Seawalls may save homes, but they starve beaches.

The development of harbors in southern California has also exacerbated erosion. Jetties and breakwaters, built to control the entrance to a harbor or inlet where boats can take shelter from waves, can halt the natural movement of sand along the beach. Sand accumulates on one side of an artificial barrier, and beach erosion accelerates on the other. The breakwater at Santa Barbara, built in 1928, is a textbook example. When the harbor became so full of sand that yachts could no longer navigate it, officials brought in a dredge to scoop up the sand and dump it on the other side of the breakwater, where the beach was rapidly eroding. Dredging continues there today; it is the only way to keep the harbor passable.

Where dredging does not occur, jetties divide a shore into clear winners and losers. Folly Beach and its ill-fated Atlantic House were losers: the sand they needed became trapped at the inlet to the harbor of Charleston. There are good reasons to construct dams on rivers—controlling floods and generating hydroelectric power among them. There are good reasons to build jetties, too. But it is important to recognize that such activities can sap our beaches.

A BEACH IS THE LIFEBLOOD OF A COASTAL community. It is the beach—much more than sea cliffs or mangrove swamps or forbidding rocky buttresses—that draws seasonal visitors to the coast, the people who stay in local hotels, eat at restaurants and buy postcards, handmade pottery, saltwater taffy and other local wares. From Cape Cod, Massachusetts, to Venice Beach, California, healthy beaches make for healthy economies. Seventy percent of Americans, when they go on vacation, visit beaches.

For that reason, the response to beach erosion in many communities has been to fight back. Massive, "hardened" structures, made of boulders, large logs or concrete, have appeared in bewildering variety. Seawalls, built along cliff faces or sand dunes, block waves before they can reach valuable property. Groins, rocky fingers built straight out into the water, trap sand in an attempt to widen the beach. Artificial reefs, built underwater from concrete or piles of stones emplaced parallel to the shore, are designed to make waves break farther than usual from the beach, thereby decreasing their destructive power. Jetties, much like groins but longer, can extend outward as far as a mile from the shore; they are constructed at inlets, where they act to keep sand from filling up harbors. Breakwaters, which are placed parallel to the shore to absorb wave energy, protect anchorages along a coast, where there is no natural harbor. And, in addition to hardening their coastlines, many communities have turned to so-called beach nourishment to restore their recreational beaches: new sand, most commonly dredged from deep water far offshore, is simply pumped onto an eroding beach.

Such solutions are expensive, however, and they do not always work. Some coastal experts have suggested, for instance, that seawalls may actually accelerate the loss of a beach. The waves that crash on a natural beach dissipate most of their energy by the time they retreat. But the waves that hit seawalls may bounce back with much of their energy intact, stirring up the sand at the base of the seawall and carrying it away.

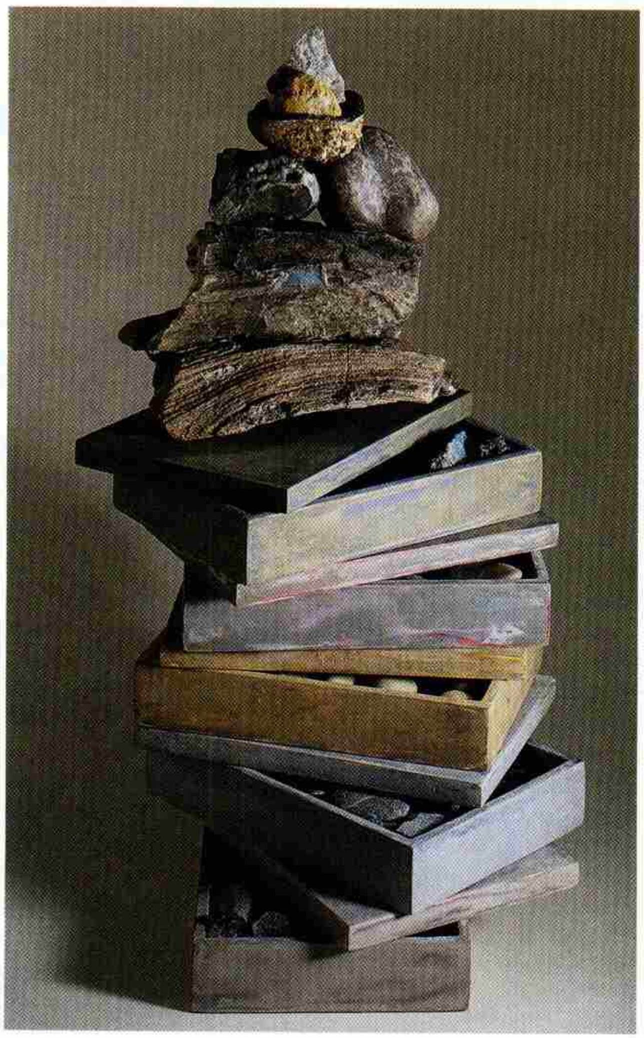
Even when engineering feats are helpful, they can be a mixed blessing. Groins, for instance, trap sand that would otherwise flow from one beach to the next; so even though groins may benefit one beach, they upset the system as a whole, depriving adjacent beaches of the sand that should have come to them via littoral drift. All too often, so-called solutions simply transfer the erosion to a neighboring community.

Although many factors underlying coastal erosion are the result of human activities, some underlying causes can be natural, too. In 1990 I journeyed to the Nile Delta in Egypt, where in some places the shoreline is retreating as fast as 600 feet a year. At that time, most experts attributed the massive retreat to the construction of the Aswan High Dam on the Nile River, which was completed in 1970.

Escorted by a team of Egyptian scientists and engineers, I traveled onto the delta, a vast green plain in the middle of the desert. Just before crossing the delta, the Nile separates into two branches, both of which flow into the Mediterranean Sea. Our first stop was near the mouth of the Rosetta Branch, which gave its name to the famous 2,000-year-old Rosetta stone. Looking out into the beautiful blue Mediterranean, I could barely make out a lighthouse, perhaps a mile offshore. Only a few years earlier the structure had been firmly on land.

The next day we traveled to the mouth of the Damietta Branch of the Nile, not far from the Suez Canal, where erosion was threatening the resort community of Ras El Bar. There, we climbed another lighthouse, close to the shore. My companion, Alfy M. Fanos, the director of the Coastal Research Institute in Alexandria, noted that the structure was the second lighthouse to be built on the Damietta Branch of the river; the first had already succumbed to erosion. He pointed inland to where a third lighthouse was under construction. By the time of my next visit, two years later, the lighthouse we had climbed had been abandoned, and, undermined by the waves, was beginning to tilt.

What caused those lighthouses to be inundated, like a child's sand castle swept away by the incoming tide? True, the Aswan High Dam did cut off the movement of sediment down the Nile, trapping it in Lake Nasser, the backup created by the dam. But at that time the dam was only a couple of decades old, whereas the erosion problems had begun in the early 1900s. Further investigation revealed the real culprit: early in the century the volume of water flowing from the Nile each year into the Mediterranean decreased abruptly. In that same period, the climate changed throughout northern and central Africa, and bodies of water such as Lake Chad began to dry up. The implication, my team realized, was that a sharp decline in rainfall around the turn of the century had reduced the amount of silt the Nile carried to the shore, and thus increased the speed of erosion. The construction of the dam had merely aggravated a problem that began with a regional climatic shift.



Janice Gordon, Stone Box 1 *(detail), 1999*

Human impacts constantly interact with natural ones to cause erosion, not only on the Nile Delta but also on barrier islands in the United States, where man-made problems have been exacerbated not by climate but by a dramatic rise in sea level. The global sea level, which has been building for the past 20,000 years, has increased six inches in the past century alone. That change has hit barrier islands particularly hard. For one thing, the weight of accumulating sand, the removal of groundwater for human use, and other factors are causing the barrier islands to sink. In addition, the gentle slope of the ground across a flat barrier island further magnifies the effect. Simple geometry implies that a small rise of the sea greatly amplifies the horizontal movement of water across the island: that amplification is typically a factor of about a hundred.

The projected net result is devastating. The adjusted rise in sea level becomes ten to fifteen inches—enough to cause shorelines on eastern barrier islands to retreat between eighty-five and 125 feet. But the true erosion levels are even greater—some 260 feet on average, and nearly 600 feet on the coast of South Carolina, according to a study by the geologist Robert Dolan of the University of Virginia in Charlottesville. In order to understand such extra-high erosion rates, one must take into account the fact that jetties have been built on nearly every inlet along the East and Gulf coasts.

That is why, whenever I give talks, whether to laypeople or to engineers and other professionals, I always remind the audience that the causes of coastal erosion are varied, complex and often far from obvious, and that they can range from a rise in sea level or a barely detectable weather pattern to a nearby harbor or a dam built 1,000 miles away.

It is perhaps understandable that people often fail to consider subtle causes of erosion that originate far away. Sometimes, however, shortsightedness can take absurdly extreme forms. During the 1982–83 El Niño, a seawall made of loose rock was built along a beach on the central Oregon coast, at Alsea Spit. The structure was successful in halting the erosion of the dunes behind the beach, and in saving the houses on the spit. Fewer storms hit during the next several winters, so the sand that had been moved offshore returned to the beach. The sand was blown about by the wind, and before long the seawall, which was built about fifteen feet high, had been completely buried.

More people built houses on Alsea Spit—now that the beach was so lovely and wide, it invited dwellings. But the major storms of the 1997–98 El Niño caused a new round of erosion. Only then did the newcomers realize that their homes had been built to the *seaward* side of the seawall. Covered by sand, the wall had been forgotten and its protective power ignored; as a result, a new seawall had to be erected to protect the second wave of homes.

Fanny Brennan, Basted Wave, *1986*

WHAT CAN BE done to keep beaches from disappearing? Somehow the lost credits in the sediment budget need to be replaced, or the debits decreased—whatever it takes to get the balance out of the red. For example, much of the sand that ends up trapped in reservoirs behind dams is often sold to sand-and-gravel companies; instead, it should be trucked to beaches, where it would resume its natural journey. But the plight of the beaches in southern California and elsewhere is so dire that more immediate measures are needed. Not enough sand is available from reservoirs, so beach nourishment—dredging sand from the continental shelf, a few miles offshore, and pumping it onto the eroded beach—has become a common solution.

But what is natural for a California beach? Many people think of wide expanses of white sand, the classic beach of television, movies and romantic advertising. But such carpets of sand are far from natural; instead, they are the product of engineering projects undertaken before and during the Second World War. Most of the harbors in southern California were created in that period—some carved out of the land, others dredged from natural bays. The easiest way to dispose of the dredged sediment was to dump it on the beach. The mud eventually washed away, but the sand remained. Although the work was not intended to nourish the beaches, its effect was just that. Reinhard E. Flick, an oceanographer at Scripps, has reviewed the historical records and found that the volume of sand dumped on southern California beaches at that time was immense—many hundreds of thousands of cubic yards a year. But since the early 1960s there has been little expansion of the harbors, and that source of sand has effectively dried up.

Whether or not beaches are natural, they are in great demand. That has generated much dissension among taxpayers, politicians and coastal scientists about what kinds of anti-erosion interventions are appropriate. In my opinion, seawalls should be banned, except when they are built to protect buildings that were constructed before there was an awareness of the erosion hazards. In my home state of Oregon, for instance, the law prohibits the erection of seawalls to protect structures built after 1976. Enough is now known about erosion to build homes that will be safe for a long time. It is possible to estimate how much erosion will take place in the next hundred years; all one needs to do, then, is build landward of those lines. Developers do not like to do that, of course; their clients want to be right on the beach—that is, until they end up in court to protest having been sold what quickly became damaged goods.

Beach nourishment offers a more natural solution than seawalls and other artificial structures, one that is particularly appropriate for correcting man-made problems. It effectively restores missing credits to the sediment budget, credits that have been eliminated by dams, harbors and other kinds of tinkering with the landscape. Beach nourishment can also pay for itself by attracting vacationers.

But beach-nourishment projects have been controversial; they are costly, and taxpayers often complain that the widened beach rapidly washes away. Part of that perception is based on a misunderstanding. After sand is pumped onto the visible part of the beach, a natural readjustment occurs. The waves recontour what is, at first, a lopsided beach, carrying much of the newly deposited sand from the dry beach into the surf zone. Unfortunately, shore residents are not always warned to expect the shift, and they mistakenly view the project as a failure.

But though beach nourishment works, it does not last forever. That would be too much to ask of a beach, which by its very nature is an entity in flux. Sand comes in and, like the grains in an hourglass, it runs out. There are no permanent fixes—and, eventually, a beach that has been cut off from its source of sand will die. Like any kind of maintenance, beach nourishment must be repeated regularly.

THOSE OF US WHO TRY TO DETER COASTAL erosion are constantly reminded of how ineffectual we human beings are when we struggle against a force as vast and powerful as the ocean. To win even the smallest victory, we have to deploy all our knowledge and foresight. We must be willing to consider our own role in creating the problem, and to adjust the cure accordingly. We will never conquer the sea. All we can do is learn its ways, become attentive to them, and, most of all, proceed with humility. ●

Paul D. Komar, *an oceanographer at Oregon State University in Corvallis, has investigated coastal erosion around the world, and is currently studying the erosion impacts of El Niño and La Niña. He is the author of* THE PACIFIC NORTHWEST COAST: LIVING WITH THE SHORES OF OREGON AND WASHINGTON.